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Wilkins et al.

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(54) **CONFIGURATION PRICE QUOTE WITH ENHANCED APPROVAL CONTROL**

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G06Q 30/02 (2012.01)
G06F 17/17 (2006.01)
G06Q 30/0283 (2023.01)

(52) **U.S. Cl.**

CPC **G06N 3/0454** (2013.01); **G06F 17/17** (2013.01); **G06N 3/0481** (2013.01); **G06Q 30/0283** (2013.01)

(58) **Field of Classification Search**

CPC **G06Q 30/02**; **G06Q 30/06**; **G06Q 30/0283**; **G06Q 30/0611**; **G06N 3/04**; **G06N 3/0454**; **G06N 3/0481**; **G06F 17/17**

See application file for complete search history.

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Primary Examiner — Kamran Afshar

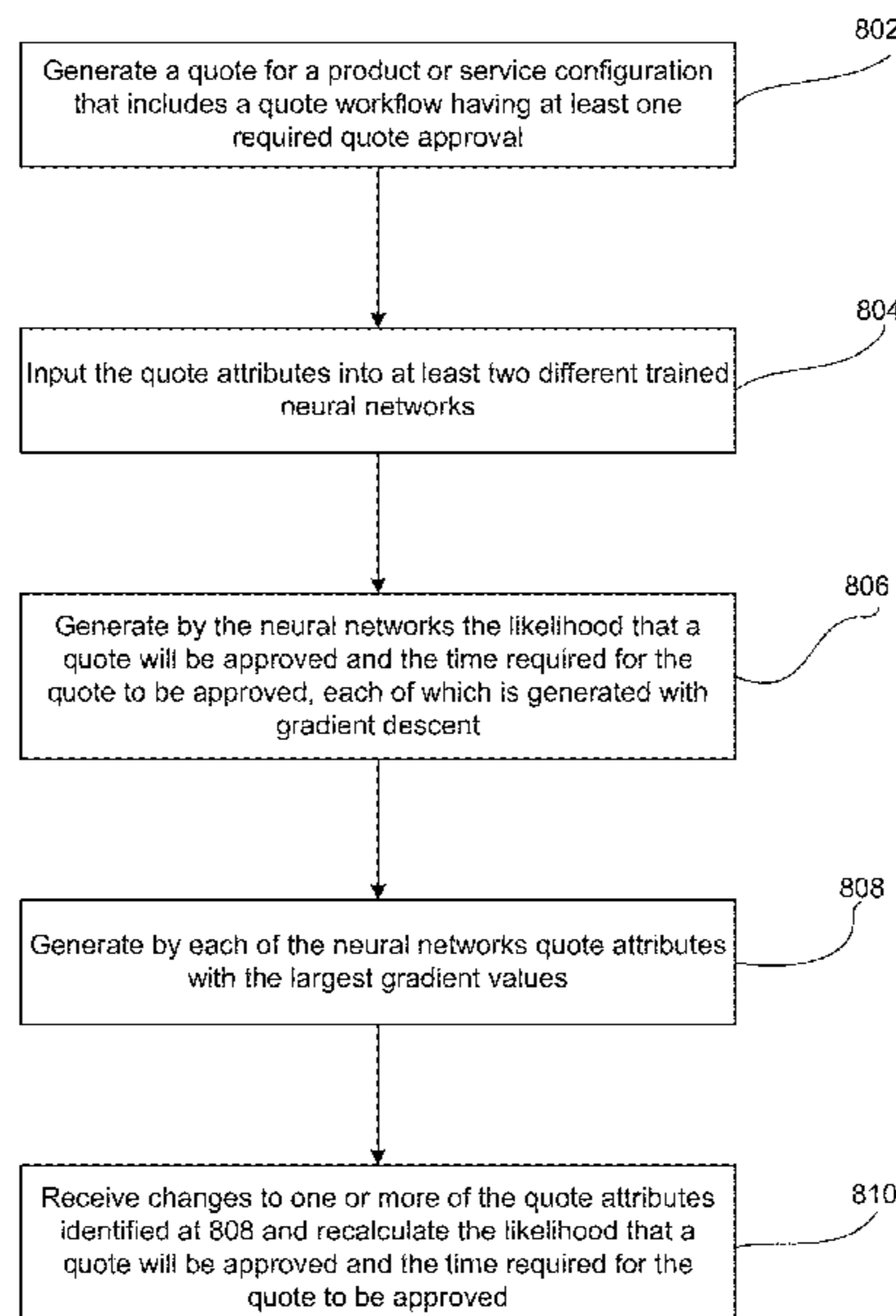
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(57) **ABSTRACT**

Embodiments operate a configurator that generates a quote for a product or service configuration, the quote including a quote workflow that includes at least one required quote approval and the quote includes a plurality of quote attributes that define the quote. Embodiments input the plurality of quote attributes into a first neural network model and a second neural network model and generate with a gradient descent a likelihood that the quote will be approved and a time required for the quote to be approved. Embodiments generate one or more attributes with the largest gradient values for the likelihood that the quote will be approved and the time required for the quote to be approved. Embodiments receive a change to one or more of the attributes and regenerate the likelihood that the quote will be approved and/or the time required for the quote to be approved based on the change.

20 Claims, 8 Drawing Sheets



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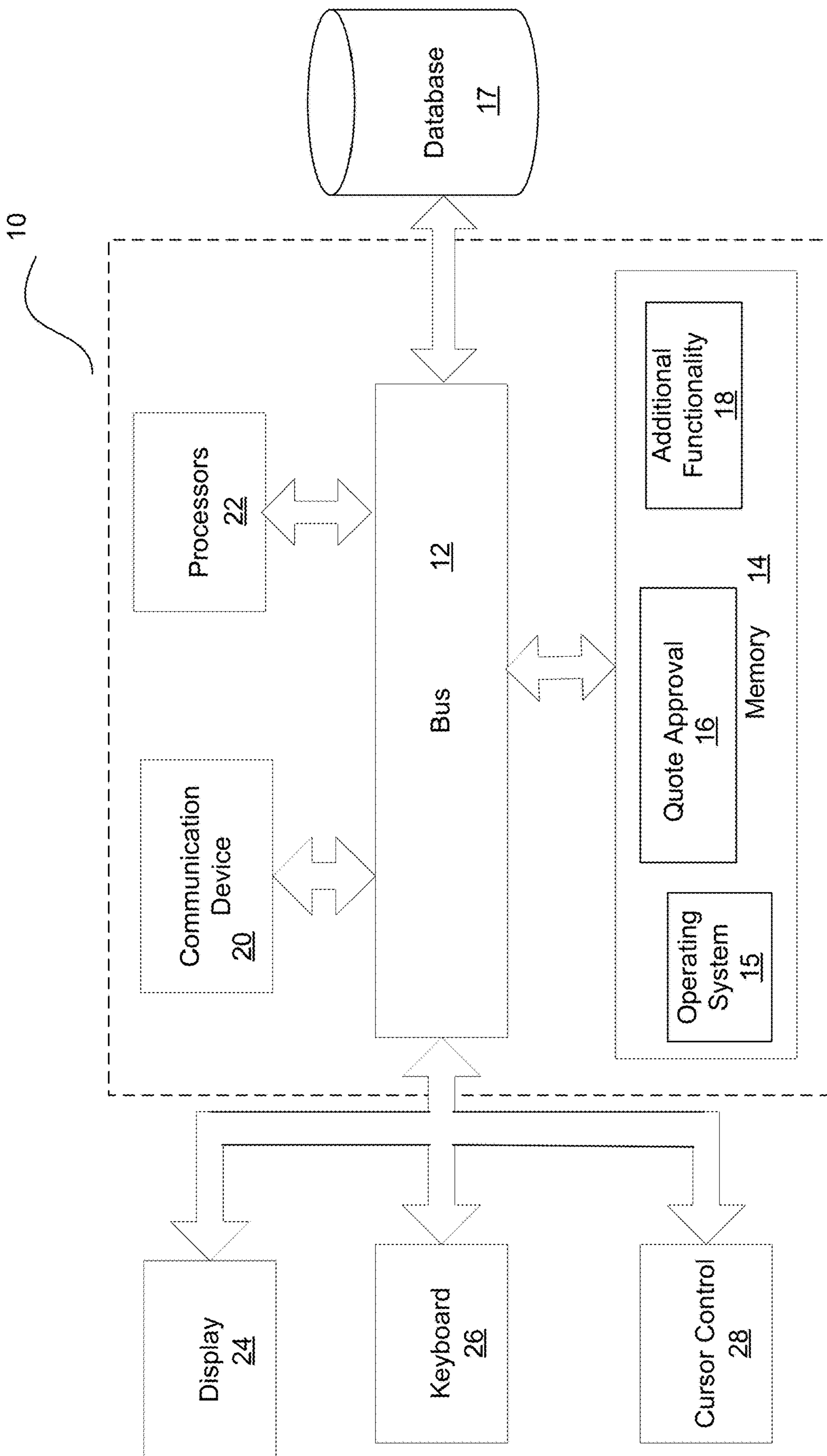


Fig. 1

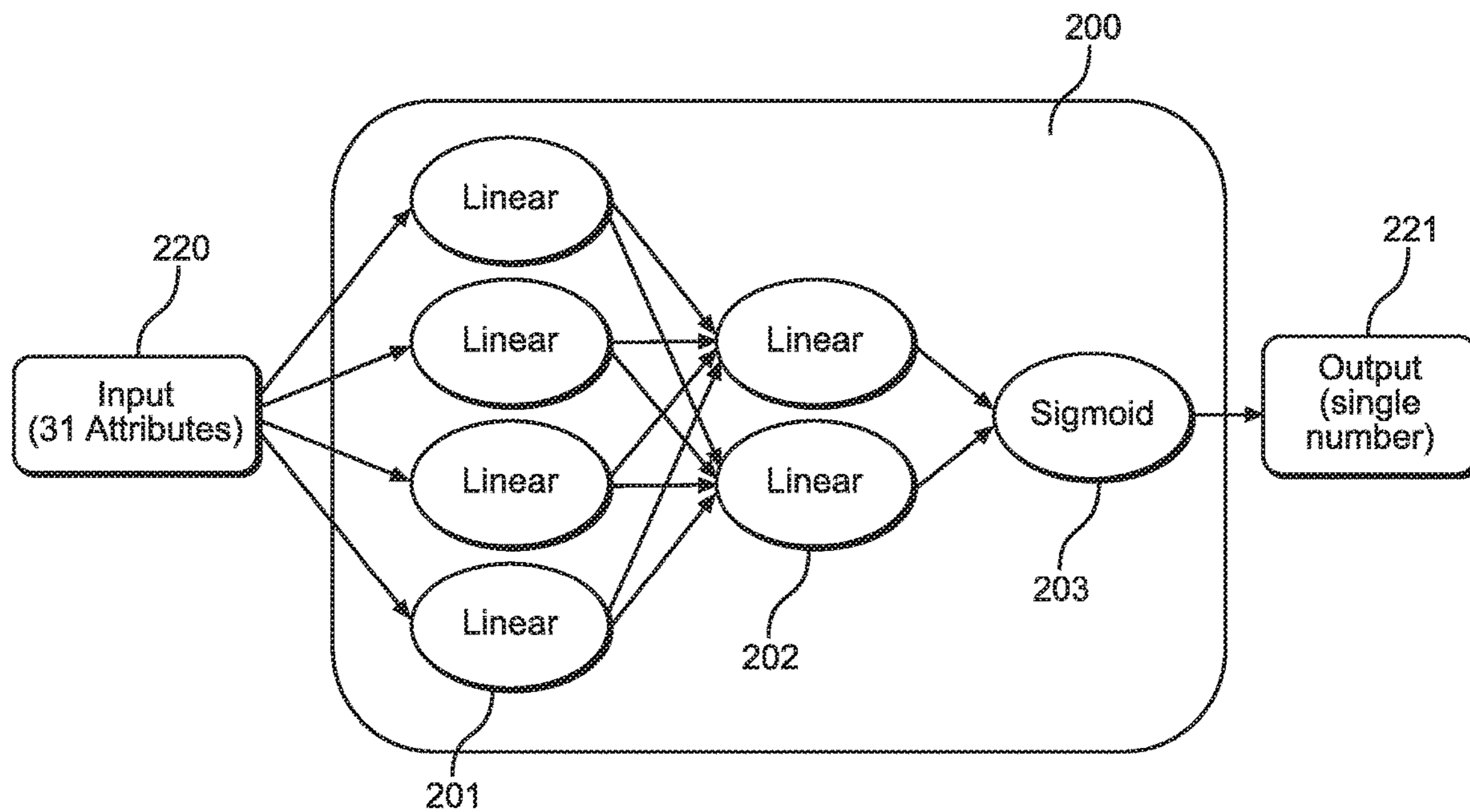


FIG. 2A

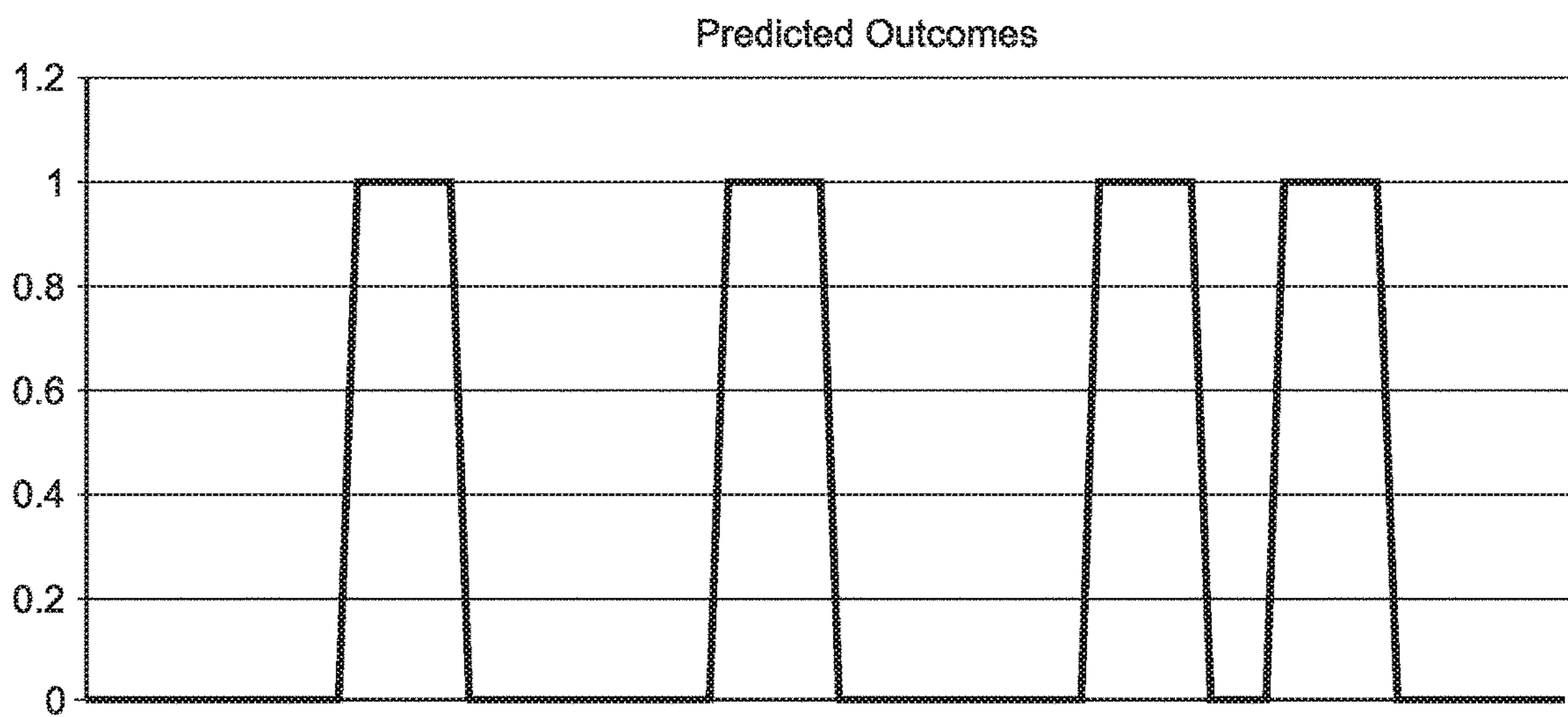


FIG. 2B

— Prediction
- - - Actual

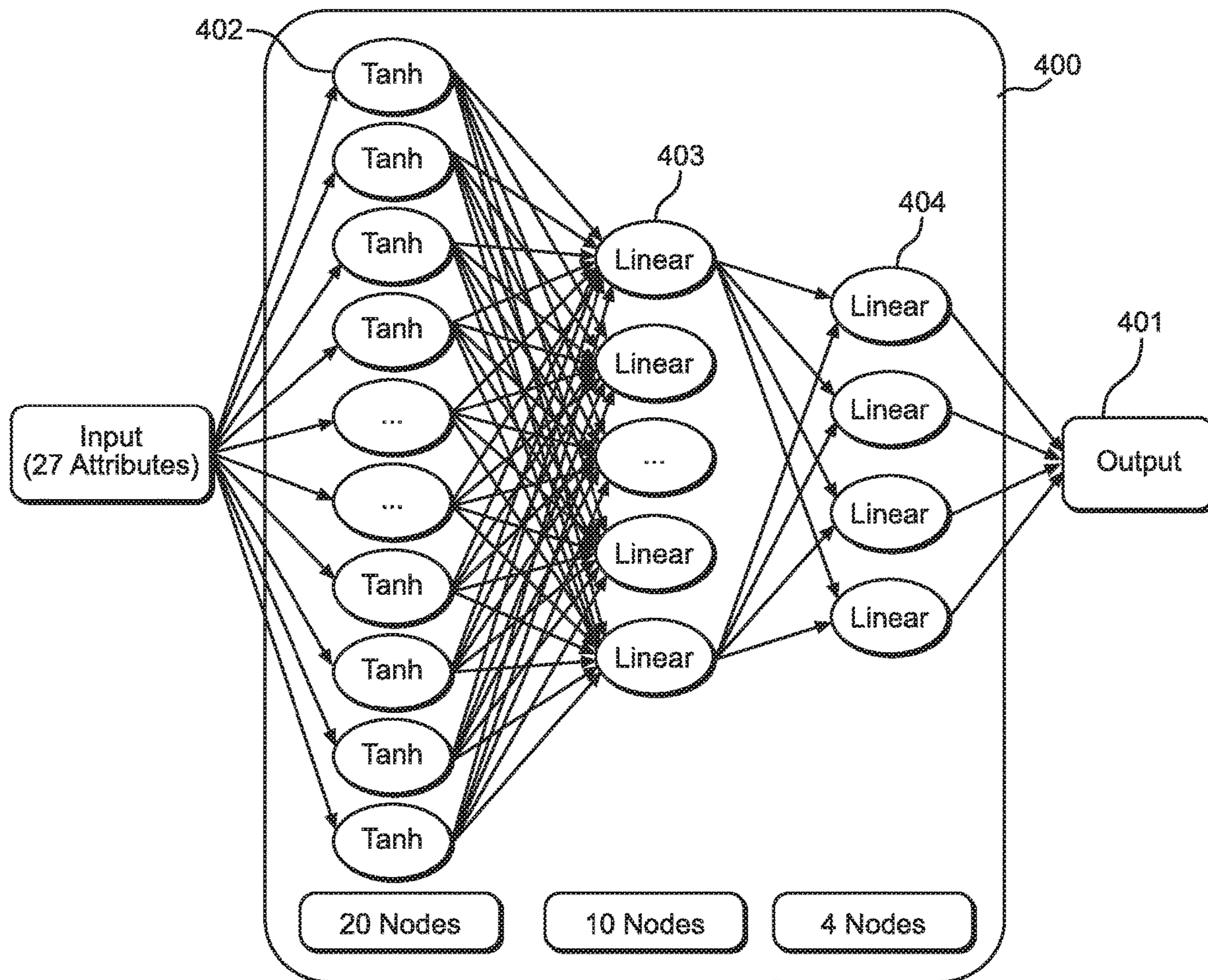


FIG. 4A

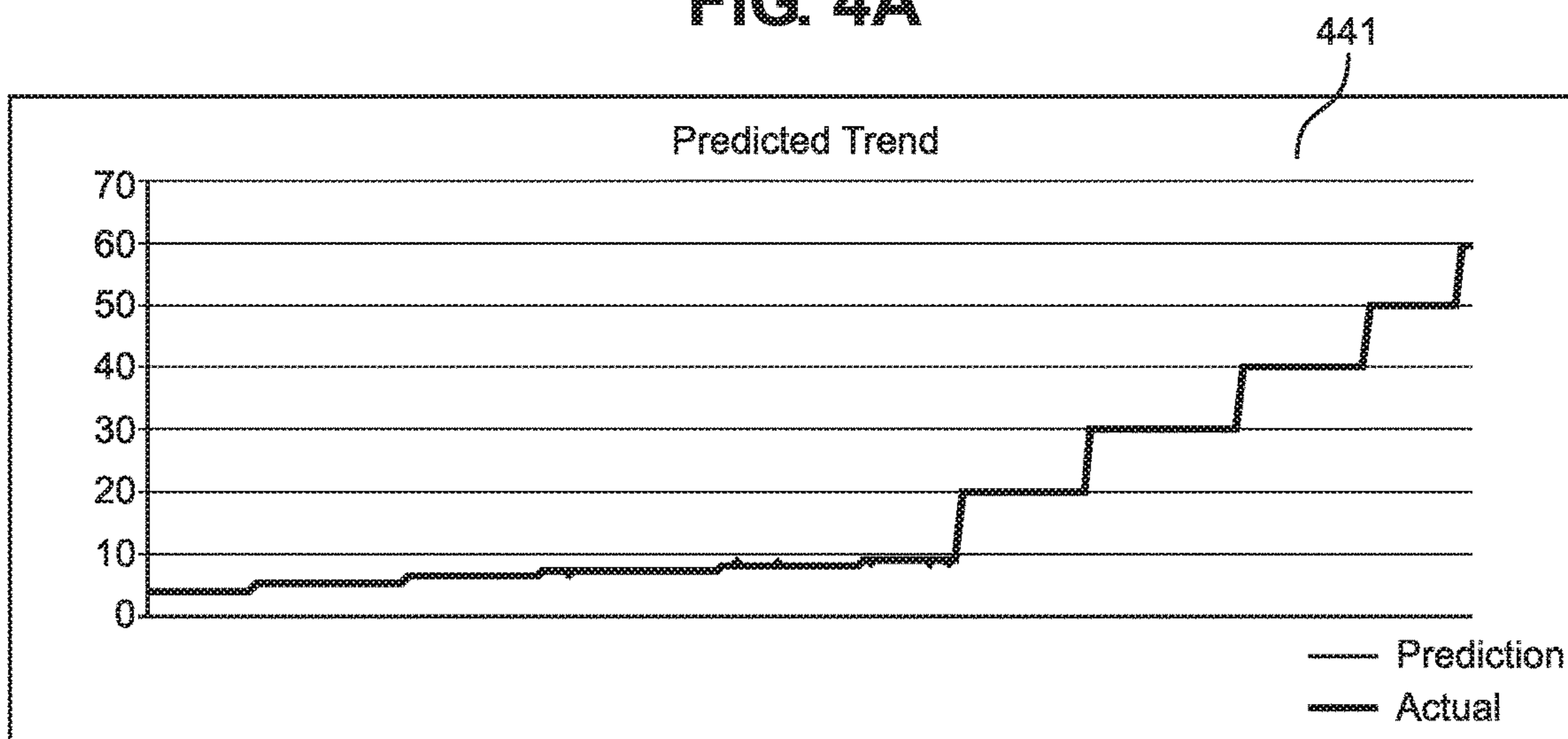


FIG. 4B

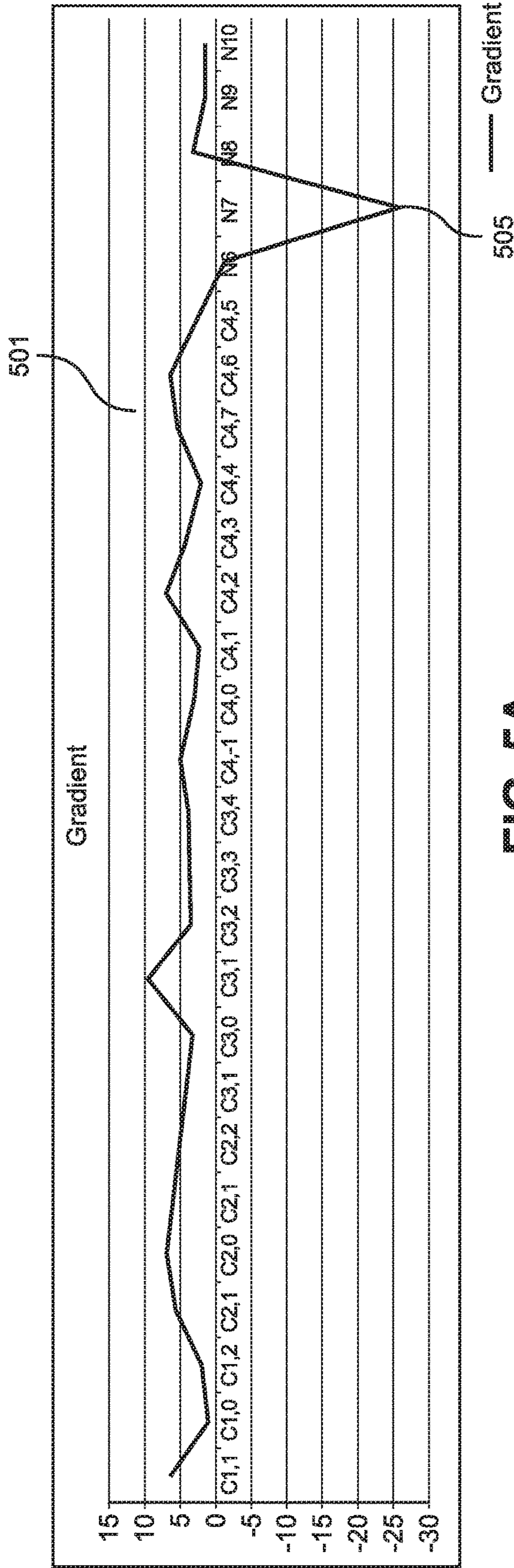


FIG. 5A

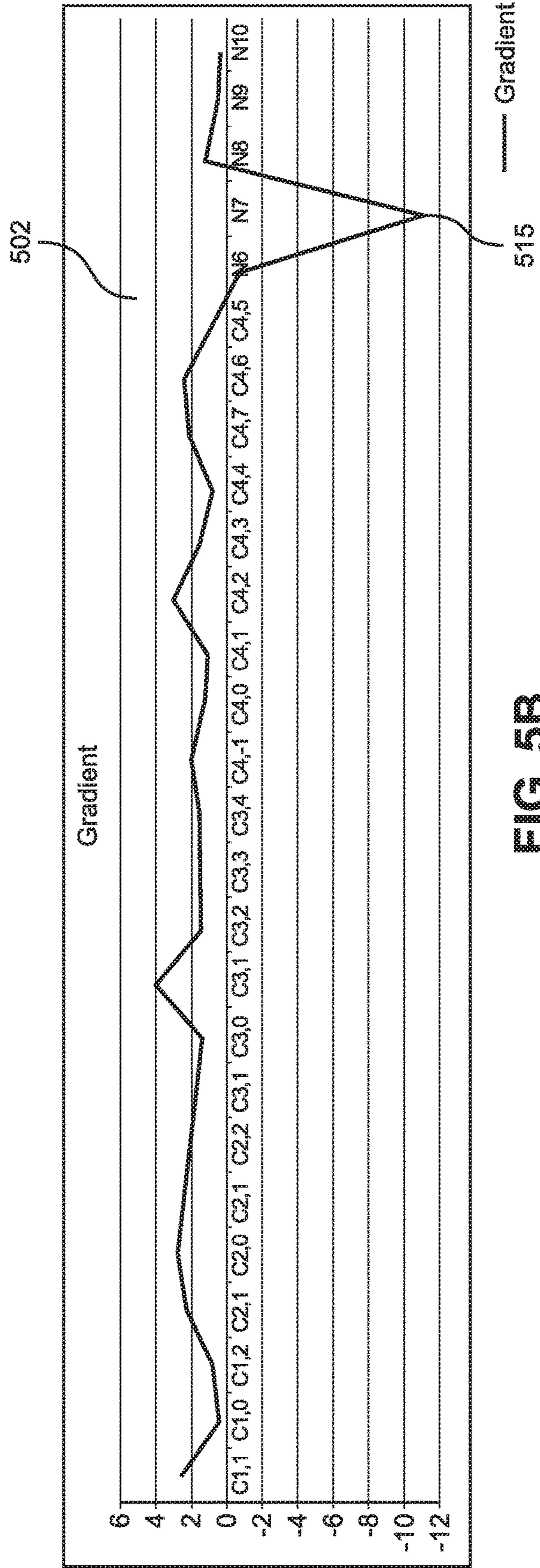


FIG. 5B

CPQ-145 : Green Server Deal

601

Transaction Details Customer Details **Approvals** Contract & Terms

Quote Name Green Server Deal

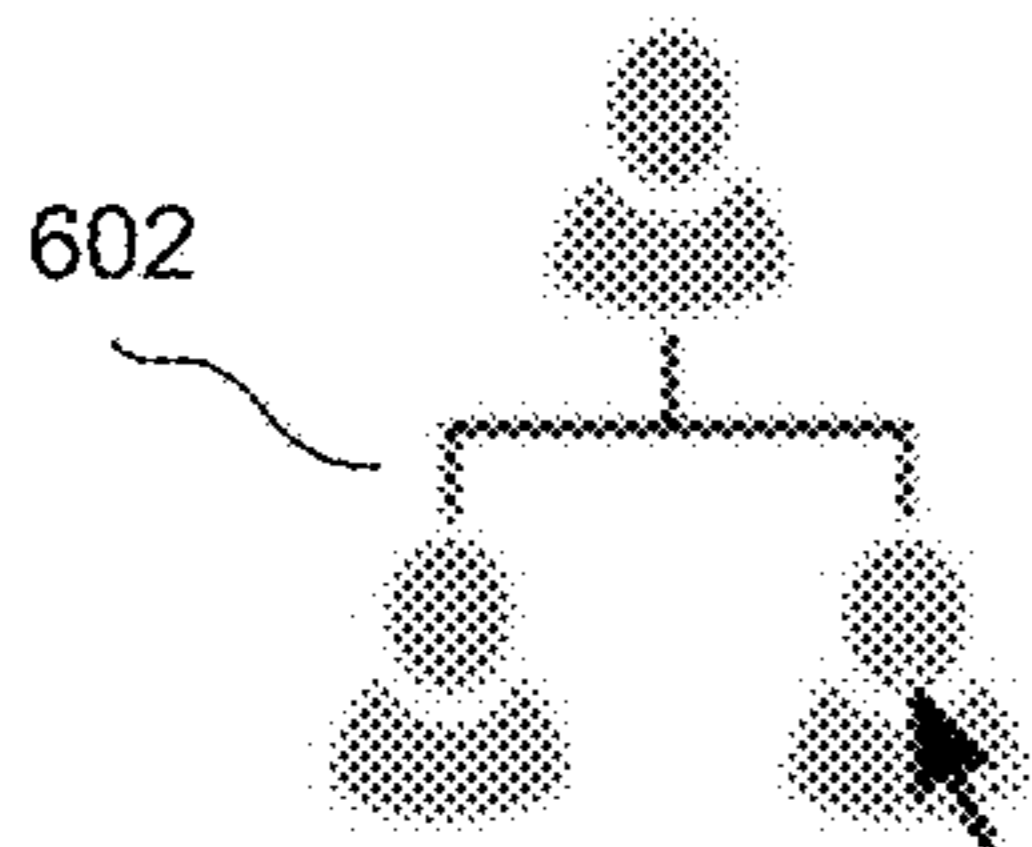
Owner Lisa Jones

Fig. 6A

Approval Status

Approvals will be required

- grace.chan[SupplyChain]-Quantity Above Threshold
- piera.lopez[Accounts]-New Account
- tai.carniere [Legal]-Contract Review



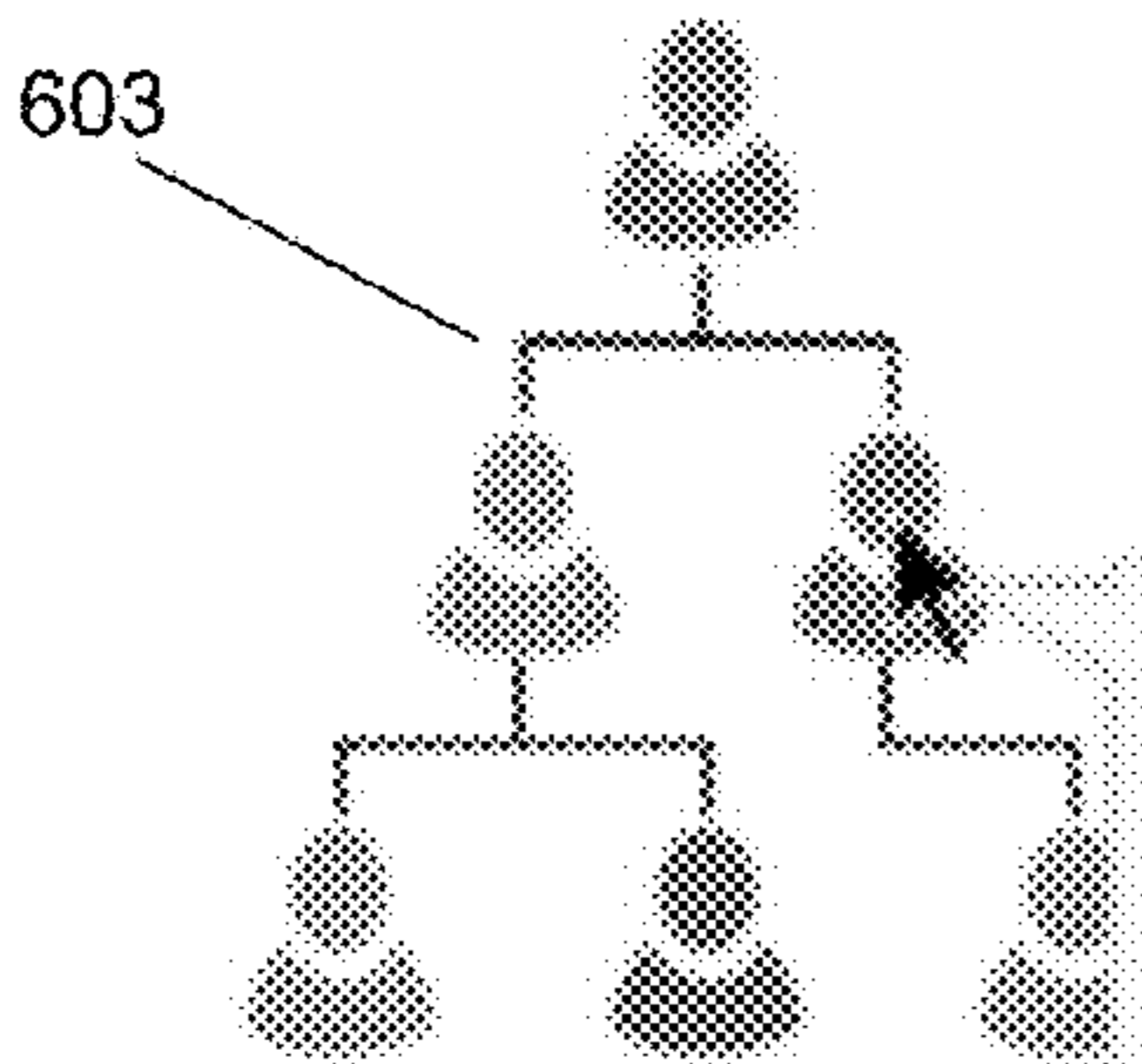
Approval required from:
tai.carniere [Legal]-Contract Review
Status: Quote In Progress

Fig. 6B

Approval Status

Currently pending approvals

- grace.chan[SupplyChain]-Quantity Above Threshold
- piera.lopez[Accounts]-New Account
- tai.carniere [Legal]-Contract Review



Approval required from:
nick.kringle[Financial]-Discount Above Threshold
Status: Approved 03/23/2018 05:30

Fig. 6C

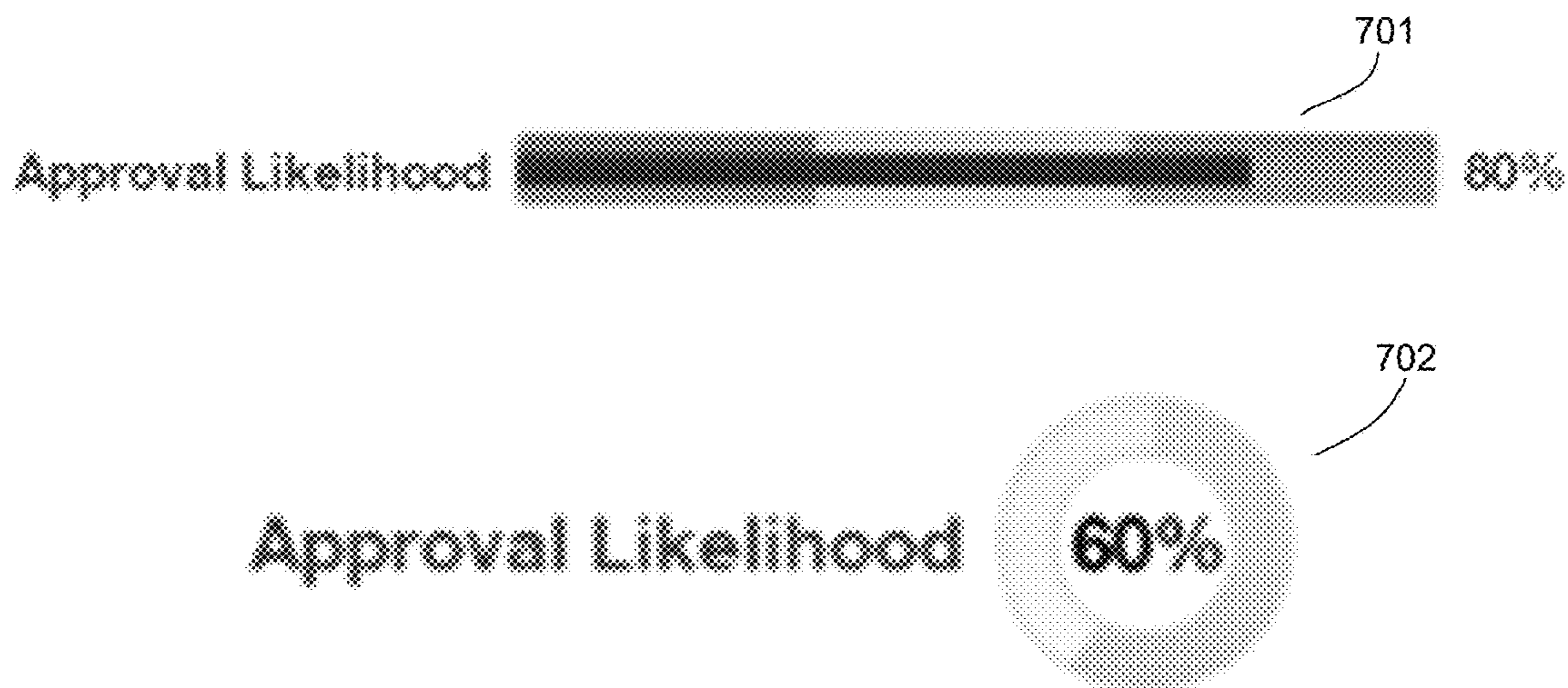


Fig. 7A

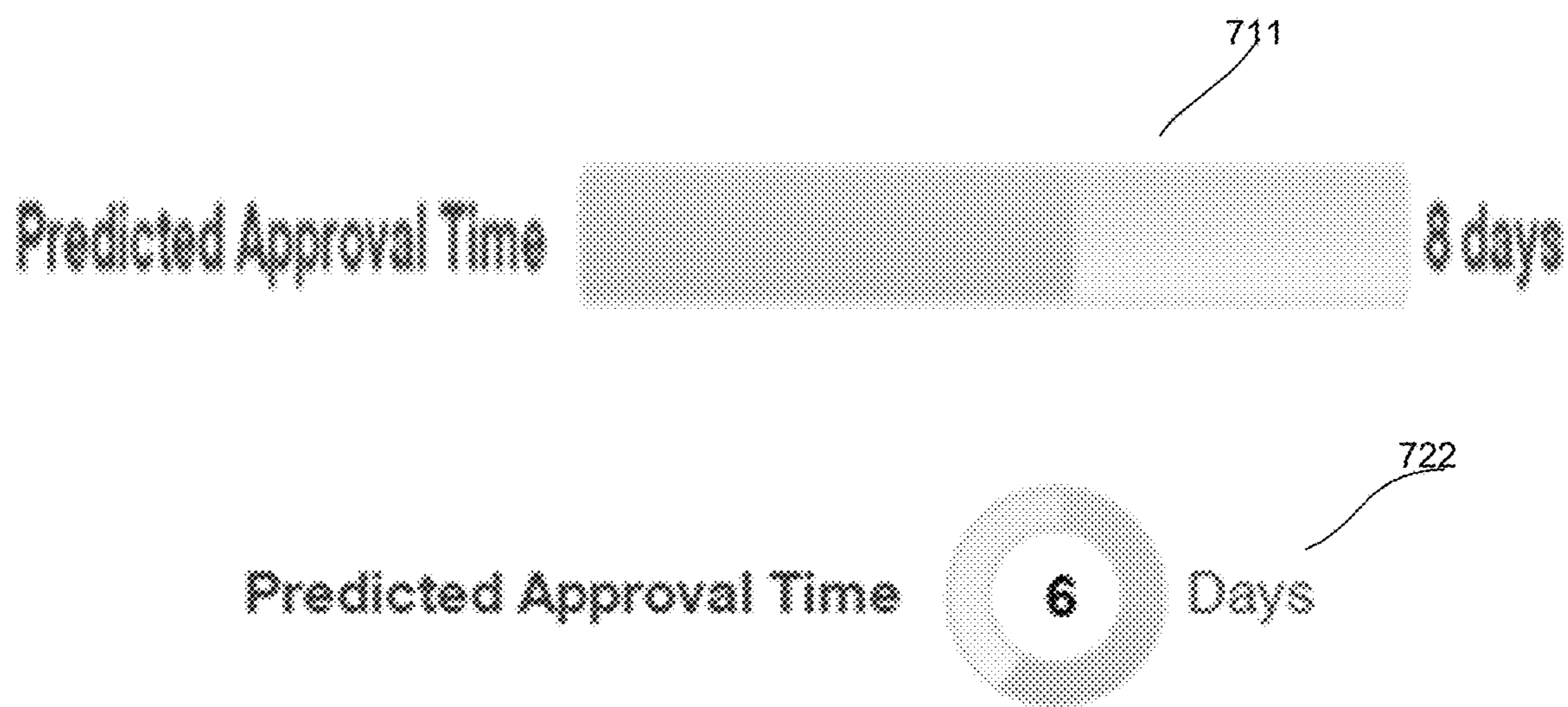


Fig. 7B

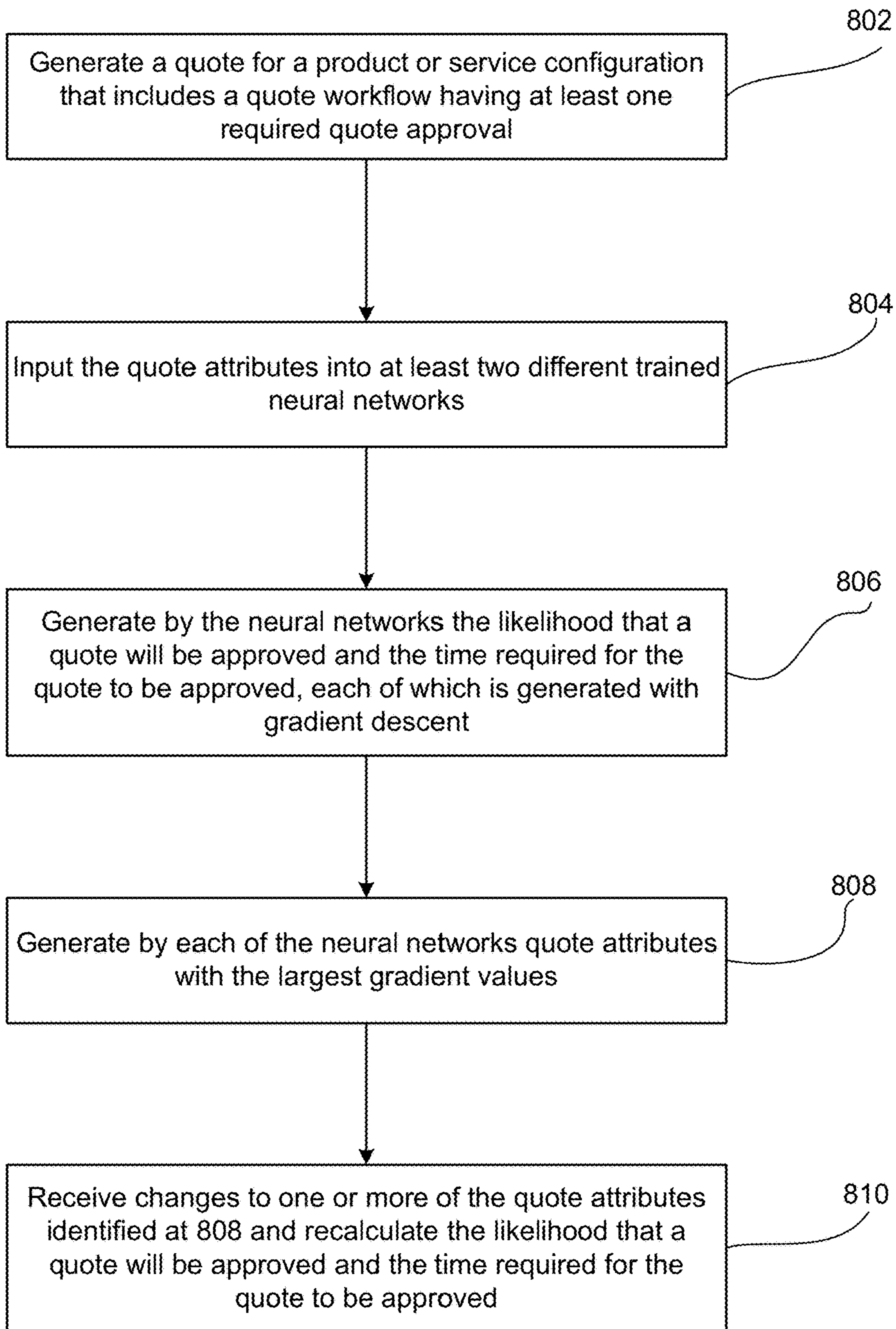


Fig. 8

1**CONFIGURATION PRICE QUOTE WITH
ENHANCED APPROVAL CONTROL**

FIELD

One embodiment is directed generally to a computer system, and in particular to the generation of product configurations and quotes with a computer system.

BACKGROUND INFORMATION

Configure-price-quote (“CPQ”) systems, also known as sales configuration systems, allow users to create a sales quotation that can include an arbitrary number of products or services (collectively, “products”), some of which may be configurable. Both products and services (such as complex financial instruments) may be configurable to generate both product configurations and services configurations.

Existing CPQ systems are designed for use by companies, typically manufacturers or service providers, who offer configurable products or services for sale. The systems are normally designed to be administered by agents of the same entity that manufactures the product. Complex configurable products used in business are often sold directly from the manufacturer to the purchasing company. These types of sales may be referred to as business-to-business or B2B transactions.

CPQ systems may facilitate the process of selling complex configurable product by automating product configuration. Business rules (“configuration rules” and “pricing rules”) that determine how the product is configured and priced may be encoded in the software application, and may be executed when the user creates a quote for the configured product. The business rules ensure that the product is correctly configured, that required product components are included, and that incompatible product options are preferably not selected. Pricing rules may apply complex logic like bundle discounts to the price.

Configurable products, especially those sold in B2B transactions, can be very complicated. Configuration and pricing rules that govern the configuration and pricing of a complex product can number in the thousands or even hundreds of thousands. Examples of such highly complex products include cellular network base stations, automated material handling system in a large warehouse, and long-haul semi tractors. Even comparatively simple products such as diesel generators, custom windows, and HVAC air handlers can have hundreds or thousands of business rules.

When configuring a product or service, a user such as a sales user typically requires approval before issuing a price quote for the configured product. The need for an approval typically relies on predefined rules in the CPQ system. For example, if a price discount of a configured product exceeds 20% and is less than 50%, a rule could require approval of a sales manager. If the price discount exceeds 50%, a rule could require approval of both a sales manager and a sales vice president.

SUMMARY

Embodiments operate a configurator that generates a quote for a product or service configuration, the quote including a quote workflow that includes at least one required quote approval and the quote includes a plurality of quote attributes that define the quote. Embodiments input the plurality of quote attributes into a first neural network model and a second neural network model. Embodiments

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generate at the first neural network model and with a gradient descent a likelihood that the quote will be approved and at the second neural network model a time required for the quote to be approved. Embodiments generate one or more attributes with the largest gradient values for the likelihood that the quote will be approved and the time required for the quote to be approved. Embodiments receive a change to one or more of the attributes and regenerate the likelihood that the quote will be approved and/or the time required for the quote to be approved based on the change.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a computer server/system in accordance with an embodiment of the present invention.

FIG. 2A illustrates an example neural network in accordance with embodiments of the invention.

FIG. 2B is a plot illustrating what is learned in accordance to embodiments.

FIG. 3 illustrates the gradient at a specific point in accordance to embodiments for each of the attributes.

FIG. 4A illustrates an example neural network that can be used to predict approval time to approve a quote in accordance to an embodiment of the invention.

FIG. 4B illustrates a graph of the modelling of an output of the neural network in accordance to an embodiment of the invention.

FIG. 5A illustrates a graph of the modelling of an output of the neural network in accordance to an embodiment of the invention.

FIG. 5B illustrates a graph of the modelling of an output of the neural network in accordance to an embodiment of the invention.

FIGS. 6A-6C illustrate graphical user interfaces that are presented to a user as part of the quote approval process in accordance to one embodiment.

FIG. 7A illustrates example graphical user interfaces that provide the output of approval likelihood to the user in accordance to embodiments.

FIG. 7B illustrates example graphical user interfaces that provide the output of predicted approval time to the user in accordance to embodiments.

FIG. 8 is a flow diagram of the high level functionality of the quote approval module of FIG. 1 when providing enhanced quote approval functionality for a CPQ in accordance with one embodiment.

DETAILED DESCRIPTION

One embodiment is a service or product configurator which provides guidance, using machine learning, on the workflow process required to get a configured quote approved, including recommending changes to a quote to increase the chance that a quote will get approved or how to decrease the time needed for approval.

In general, with known CPQ or configurator systems, sales users submitting quotes for approval are given no indication what is likely to happen next or how long this step is likely to take. The user is also generally blind to how likely the quote is to get approved or the expected time that it will take. Further, with known systems there generally is no guidance to recommend anything else that the user could do to make an approval more likely or to decrease the time to approve.

FIG. 1 is a block diagram of a computer server/system in accordance with an embodiment of the present invention. Although shown as a single system, the functionality of

system **10** can be implemented as a distributed system. Further, the functionality disclosed herein can be implemented on separate servers or devices that may be coupled together over a network. Further, one or more components of system **10** may not be included. For example, for functionality of a server, system **10** may need to include a processor and memory, but may not include one or more of the other components shown in FIG. **1**, such as a keyboard or display.

System **10** includes a bus **12** or other communication mechanism for communicating information, and a processor **22** coupled to bus **12** for processing information. Processor **22** may be any type of general or specific purpose processor. System **10** further includes a memory **14** for storing information and instructions to be executed by processor **22**. Memory **14** can be comprised of any combination of random access memory (“RAM”), read only memory (“ROM”), static storage such as a magnetic or optical disk, or any other type of computer readable media. System **10** further includes a communication device **20**, such as a network interface card, to provide access to a network. Therefore, a user may interface with system **10** directly, or remotely through a network, or any other method.

Computer readable media may be any available media that can be accessed by processor **22** and includes both volatile and nonvolatile media, removable and non-removable media, and communication media. Communication media may include computer readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism, and includes any information delivery media.

Processor **22** is further coupled via bus **12** to a display **24**, such as a Liquid Crystal Display (“LCD”). A keyboard **26** and a cursor control device **28**, such as a computer mouse, are further coupled to bus **12** to enable a user to interface with system **10**.

In one embodiment, memory **14** stores software modules that provide functionality when executed by processor **22**. The modules include an operating system **15** that provides operating system functionality for system **10**. The modules further include a quote approval module **16** that provides enhanced quote approval functionality for a CPQ, and all other functionality disclosed herein. System **10** can be part of a larger system that uses the disclosed quote approval functionality, such as a CPQ system (e.g., “CPQ Cloud” from Oracle Corp.) or an Enterprise resource planning (“ERP”) system. Therefore, system **10** can include one or more additional functional modules **18** to include the additional functionality. When processor **22** executes at least software module **16**, system **10** becomes a special purpose computer provides enhanced quote approval functionality as disclosed herein.

A database **17** is coupled to bus **12** to provide centralized storage for modules **16** and **18** and store product attributes, financial data, inventory information, sales data, etc., and all other data needed for modules **15**, **16** and/or **18**. In one embodiment, database **17** is a relational database management system (“RDBMS”) that can use Structured Query Language (“SQL”) to manage the stored data. Database **17** may be local to the other components of FIG. **1**, or remote such as on the cloud.

In one embodiment, particularly when there are a large number of configuration details to be searched, database **17** is implemented as an in-memory database (“IMDB”). An IMDB is a database management system that primarily relies on main memory for computer data storage. It is contrasted with database management systems that employ

a disk storage mechanism. Main memory databases are faster than disk-optimized databases because disk access is slower than memory access, the internal optimization algorithms are simpler and execute fewer CPU instructions. Accessing data in memory eliminates seek time when querying the data, which provides faster and more predictable performance than disk.

In one embodiment, database **17**, when implemented as an IMDB, is implemented based on a distributed data grid. A distributed data grid is a system in which a collection of computer servers work together in one or more clusters to manage information and related operations, such as computations, within a distributed or clustered environment. A distributed data grid can be used to manage application objects and data that are shared across the servers. A distributed data grid provides low response time, high throughput, predictable scalability, continuous availability, and information reliability. In particular examples, distributed data grids, such as, e.g., the “Oracle Coherence” data grid from Oracle Corp., store information in-memory to achieve higher performance, and employ redundancy in keeping copies of that information synchronized across multiple servers, thus ensuring resiliency of the system and continued availability of the data in the event of failure of a server.

In one embodiment, system **10** is a computing/data processing system including an application or collection of distributed applications for enterprise organizations. The applications and computing system **10** may be configured to operate with or be implemented as a cloud-based networking system, a soft are-as-a-service (“SaaS”) architecture, or other type of computing solution.

As disclosed above, a CPQ system or product/system configurator can generate a configuration and pricing for the configuration that is offered for sale to a user in the form of a quote. Typically, depending on predefined rules, the quote must be approved before being offered for sale. In embodiments, a quote approval is a step in a quote workflow that must pass before a quote can be sent to fulfillment services. Known systems such as “CPQ Cloud” from Oracle Corp. allow an administrator the ability to generate a tree based approval structure, forcing users to get approval from every node on the tree before the quote can be processed through the approval.

Quotes within known CPQ systems are processed through a customer defined workflow. This creates the steps that a quote can occupy, the actions that will move between the steps and the permission of each user able to view the quote at each step. One such specialized step is the submit for approval step. When that happens, the quote enters an approval hierarchy. This hierarchy defines a tree of approvals that must happen in a specified order before the quote is allowed to exit the pending approval state and be fully approved. Every node in the tree has rules defined to specify when that node should become active. For example, if a quote has a discount exceeding 20%, a rule may state that the quote needs managerial approval. This node only turns on when that discount is exceeded. Otherwise the node is bypassed.

In contrast to known CPQ systems, embodiments add a machine learning component to the end user approvals process to provide guidance on how the approval is likely to flow. Embodiments further provide guidance on what changes can be made to the quote to change the workflow of the quote (e.g., reduce the time required for approval). The guidance in embodiments is directed to the time an approval takes and the likelihood of the quote to get approved.

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Embodiments provide functionality in three key areas to increase and enhance end user knowledge about the state of the quote: (1) Approvals status indication; (2) Approvals likelihood indication; and/or (3) Approvals time indication.

In embodiments, approvals take the form of a graph of nodes. Every level of approval can include multiple nodes and levels can be arranged in any order. A rejection in any approval node will result in a rejection of the full quote. Approval nodes must be navigated in order.

The approvals data are maintained in embodiments as a step in the quote workflow. That step has two outcomes (i.e., approved or rejected), and a time value (i.e., how long the quote existed at this step). The quote also maintains the attribute values of the quote at the time the quote moved into the pending approvals state. Attributes of the quote are any information related to the product or service that is the subject of the quote or the quote itself. Example attributes include a discount percentage of the quote (i.e., a numerical attribute), a line item total, the state of the purchase (i.e., a categorical attribute), the name of the person purchasing, etc.

The following are examples of a quote and quote attributes where approvals are triggered and can be enhanced using the functionality of embodiments of the invention:

Assume that a forklift is being sold by an equipment manufacturer to a loyal customer. The sales user adds a 35% discount for the customer because of their loyalty. This is above the standard limit of a 20% discount so direct manager approval is required.

Assume a gaming system is being sold. Due to the technology embedded in the system, export laws may be in effect. When the quote enters approval, the "Export" option is set to true, which triggers specific legal/security approval.

Assume a one off quote is being created for a customer who recently completed a large bulk order. Because of the previous order, the sales user selects the "Bulk Discount" option. When this option is selected on orders with fewer than 100 items, an approval from a Vice President ("VP") is required.

Assume a large order of generators is submitted to the system consisting of more than 100 tons of product to be shipped. This triggers an approval from the firm's logistics department to make sure the company is capable to ship the requested items.

Assume several cranes are ordered requesting a specialized high strength steel cable. The supply of this steel cable is low. Therefore, the existence of this type of cable in the parts list on the quote triggers approval from the VP of the supply division of the company to make sure the required materials are in stock.

Assume a sale is made for mining services with a foreign government. When the quote is pushed to the approval system, the fact that it is selling to a foreign government triggers a specific Foreign Corrupt Practices Act ("FCPA") review approval step in the flow.

Embodiments feed this data into a machine learning system to train the system. Specifically, embodiments feed in a past historical set of all quote attributes (or a relevant subset) and whether or not the quote was approved or the time taken for the quote to be approved. In order to find the relationship between attributes and approval likelihood (or approval time), any machine learning system can be used in embodiments. In one embodiment, the machine learning system is a neural network of linear neurons. After training the machine learning system, embodiments generate two functions: one mapping the set of attributes "{a}" to the

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likelihood of getting an approval and one mapping the set of attributes to the time that an approval will take. The functions are defined as follows:

Likelihood=L({a}): Generated by the set containing all quote attribute values and the approve/reject data for each quote.

Time=T({a}): Generated by the set containing all quote attribute values and the approval step time length for each quote.

Both these functions are generated by the machine learning algorithm and will relate a quote attribute vector to a percentage likelihood of approval component or an absolute time value.

In embodiments, the machine learning system that generates the above two functions does so with gradient descent. Specifically, it iteratively calculates the gradient of the loss function at each neuron and moves the coefficient weights for each input attribute in the direction of a smaller loss. During training of a function $f_n(\{a\})$, for each input data point passed in ($\{a'\}$), two elements are calculated:

1. The current function's predicted value for $\{a'\}$ ($f_n(\{a'\})$) and how much that value differs from the known value associated to $\{a'\}$ in the training data set. The difference between the predicted value and the actual value is the error of the function for the current iteration. The variables of any loss function will in fact be the weights defined on each node in the function's neural network. That is, the loss function will be a function of all of the node coefficients.

2. Since $f_n(\cdot)$ is a known function (it is determined when the topology of the network is chosen), the gradient of the loss function can be calculated. To find where the minimum of this loss function is (which in real terms is the best predicted match of the function to the inputs), the coefficients are changed by a small amount in the most negative direction of the gradient. That is, the function $f_n(\cdot)$ is changed slightly as determined by the gradient taken on the coefficients of the function. Subsequently, a new function $f_{n+1}(\cdot)$ is determined. The same process is repeated many times until the algorithm is able to come very close to making the error 0.

As a result of the above, the optimal function is achieved. Embodiments answer the question of, given the present likelihood or time to approve values of each quote, what changes can be made to the quote to make the likelihood or time rise or fall. Since the gradient of the existing function is being calculated, attributes that would best influence the dependent variables of likelihood and time can be calculated.

Therefore, embodiments calculate the real number gradient (which is the n-dimensional slope of the likelihood or time prediction curve) and produce a weighted list for all relevant attributes of how significantly they influence the outcome. With this information, embodiments display to the user an indication of which changes should be made to the quote for optimal approval length and provide next step guidance to users. In general, the larger the gradient component for each attribute's weight, the more impact it has on moving the likelihood or the time to approve values.

Example 1

As an example of an embodiment, assume the following data set that includes 10 attributes, including categorical attributes (C1-C4) and numerical attributes (N5-N10):

Category C1	Category C2	Category C3	Category C4	Number N5	Number N6	Number N7	Number N8	Number N9	Number N10	Output - Likelihood	Output - Time
0	0	2	3	6.495143243	53.9853464	5	95.53986856	133.1543239	77.16217789	0	—
0	0	5	4	4.28987575	26.29129	15	27.312201	877.8658642	79.18299751	0	—
1	0	5	6	8.359881903	83.18348815	25	55.81503377	585.8442464	44.01166209	0	—
0	0	1	2	0.676883994	18.78680912	35	79.95464265	993.9859001	8.332405084	0	—
0	0	4	5	8.238647227	37.99070649	45	43.84775709	302.5998108	19.10696119	0	—
0	0	5	5	8.762606549	80.09452557	55	26.91453956	658.7310311	23.84139879	0	—
1	0	5	3	1.205636375	2.130799802	65	75.95235444	132.5033435	15.1053647	0	—
1	0	0	3	8.08752456	44.25132011	75	87.09241396	502.5093922	73.47849466	0	—
2	0	3	5	6.895272877	38.09947629	85	60.83298284	820.800703	9.20832436	0	—
0	0	4	0	6.813409027	14.93003907	95	93.83992596	530.6350765	40.92407365	0	—
1	1	2	5	0.965404344	0.403228222	10	14.06325369	704.783014	4.353862791	0	—
2	1	2	1	5.704165475	62.23064143	20	28.81185361	997.2275939	79.01969311	0	—
2	1	0	2	9.830447174	99.12768992	30	50.74409529	863.9507489	42.08984358	0	—
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1	1	2	3	9.203771522	9.565180145	60	95.41335892	592.0795505	25.45765682	1	6
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1	1	2	6	9.542795389	77.72751437	100	78.28769594	745.5394366	26.13156397	1	10
2	2	1	4	1.316697914	4.210211855	2	47.97478217	554.871315	32.9139452	0	—
1	2	0	7	1.182550654	78.83828041	12	58.77908738	561.6066324	8.174007162	0	—
2	2	5	4	8.24211997	31.70889565	22	57.28061573	776.6692518	40.79519692	0	—
2	2	1	0	7.306281259	90.55238681	32	42.83466061	300.6493848	17.15215289	0	—
0	2	4	5	3.329868147	82.40462823	42	35.77223375	263.1093391	91.80904775	0	—
2	2	3	7	7.553491735	48.08013882	52	34.55662006	851.873763	57.44285319	0	—
2	2	1	4	6.119757798	93.89690198	62	96.5696378	159.0307283	77.10025786	0	—
0	2	4	0	3.649884292	60.4204693	72	92.09081777	688.7255506	18.43600676	0	—
1	2	5	2	9.78802884	94.56270594	82	39.07038234	492.6542277	55.61828996	0	—
1	2	2	3	3.066745444	90.45104174	92	19.64472227	325.4636196	68.99485025	0	—
1	3	1	6	2.697107981	73.79984882	8	40.43612699	483.5938179	68.49541422	0	—
1	3	5	7	8.069590219	34.0801769	18	62.35311437	37.74981167	38.29375811	0	—
2	3	3	0	2.042267925	94.9607249	28	27.75552481	754.5874632	22.88024778	0	—
0	3	1	7	8.247930202	53.21745125	38	96.76960283	760.2352187	18.14208914	0	—
2	3	1	6	4.726675105	3.059525703	48	43.2362592	464.6885407	15.25987279	1	4
0	3	0	1	9.555521685	10.39694234	58	53.78839166	703.9343386	69.54174297	1	5
2	3	0	7	0.495636078	22.76949234	68	63.24197486	711.841831	42.45496713	1	6
0	3	1	0	6.751326015	71.10342741	78	22.58962468	526.9667257	63.65592691	1	7
2	3	0	4	6.237390634	46.48728978	88	93.43233288	669.0006737	82.12466115	1	8
2	3	0	7	6.238268211	96.98075558	98	58.82812759	358.2251893	91.69766715	1	9
2	4	3	1	8.003196394	8.847137267	5	80.66788247	626.1682598	68.33429156	0	—
0	4	0	3	4.307905839	56.42973991	15	71.96930535	411.810744	12.29264395	0	—
2	4	5	6	3.976796721	7.799382212	25	74.62998472	489.2832926	40.61929822	0	—
1	4	0	7	3.97266237	35.95729578	35	78.70387251	682.7084834	31.90423582	0	—
0	4	1	3	7.604834382	75.50467657	45	39.84645074	111.5171441	91.48233839	0	—
0	4	0	2	4.996883102	70.06843531	55	83.59217329	812.8300317	7.843340358	0	—
0	4	3	1	7.015827769	55.28246733	65	81.94566239	129.7957661	68.74736348	0	—
0	4	3	6	4.065114409	97.02989251	75	18.00260994	625.4247656	78.69127581	0	—
1	4	3	4	4.324621738	40.8456703	85	61.13157492	441.3954103	55.08237328	0	—
0	4	3	4	3.836406529	42.50234014	95	85.28806839	85.03476386	75.88278946	0	—
2	5	0	3	7.682416956	90.34635423	10	51.67117426	162.2451052	19.85602748	0	—
0	5	3	5	7.168145995	12.69416286	20	71.53580733	985.7035345	53.20130898	0	—
1	5	5	7	7.032183037	13.03787014	30	35.14322025	366.4873761	59.9987608	0	—
0	5	1	6	4.581931133	19.39318853	40	21.59277583	42.25188125	98.95609029	0	—
1	5	4	1	2.266865818	96.31761469	50	36.82893657	949.4385477	57.11249479	1	5
1	5	5	6	3.051406526	20.2750649	60	29.42651338	906.9905431	34.24244388	1	6
1	5	1	1	3.105063975	19.67657258	70	27.27329798	539.5347717	76.87417928	1	7
1	5	4	0	2.199206195	97.20727944	80	44.46675948	771.6102853	57.26193252	1	8
2	5	0	7	6.564855845	12.91607262	90	14.6740276	801.376424	27.59289244	1	9
2	5	2	5	5.648447451	48.22651076	100	39.85244275	820.7554917	49.80879935	1	10
1	6	2	6	1.892033167	92.80558197	2	71.43602812	337.9507061	0.728105276	0	—
2	6	3	5	6.373304937	66.85105096	12	93.41451029	34.03630356	5.47131845	0	—
2	6	0	1	7.296211744	42.69165347	22	0.434677244	354.2164082	77.90157551	0	—
2	6	1	4	2.884692548	74.41621668	32	11.57148021	931.650732	31.41866876	0	—
1	6	3	0	2.403970391	23.35716644	42	37.5433218	943.6238633	7.299101732	1	4
0	6	1	5	5.330855691	1.190311401	52	28.69430394	16.1586225	12.90661019	1	5
0	6	4	3	3.52921779	9.54434225	62	8.38418883	515.5626844	8.713613946	1	6
1	6	4	1	5.661196606	1.007811055	72	73.41749298	795.7179208	81.26549621	1	7
1	6	0	3	1.936351717	8.484136103	82	28.90585109	920.9110479	0.104209306	1	8
0	6	3	2	1.7675365	72.44685554	92	23.59218702	916.3472004	99.01433504	1	9
2	7	0	5	8.423889874	4.918727995	8	84.74185765	907.1421197	14.63253682	0	—
0	7	1	1	0.608424857	19.80320644	18	68.86162145	173.2821681	89.02432982	0	—
2	7	1	3	0.126053549	72.99953176	28	58.76472584	492.4968169	13.73737802	0	—
2	7	0	1	8.286207653	96.89421913	38	22.20598667	619.1454077	7.859572483	0	—
2	7	3	7	7.967299076	19.58671346	48	39.56717033	601.0277005	65.08421536	0	—
1	7	2	0	9.426754359	68.61866497	58	32.64333259	296.9889355	23.70218536	0	—
1	7	3	2	9.817267172	38.93276124	68	96.69494088	34.72554938	30.60536923	0	—

-continued

Category C1	Category C2	Category C3	Category C4	Number N5	Number N6	Number N7	Number N8	Number N9	Number N10	Output - Like- lihood	Output - Time
0	7	3	0	3.787458108	32.12792726	78	44.87562694	290.9502401	47.06539502	0	—
1	7	3	7	3.120871341	7.970666955	88	14.77640024	555.2521601	15.5228988	0	—
1	7	4	0	4.868490562	6.221691269	98	88.26246109	116.1817146	60.16236017	0	—

Category 2 (C2) and number 7 (N7) are the only two components of real data in this simplified example. The rest are randomly generated noise in the example, because only changes in C2 and N7 have any effect on the output likelihood value. Having noise shows how the algorithm can discern the determining factors. The underlying relationship in the above data is the following:

If C2 is in (1, 3, 5, 6) and N7>40, the quote will be approved. The time for approval is directly proportional to the value of N7.

If C2 is in (0, 2, 4, 7), the quote is not approved.

In the above example, there is a mixture of categorical and numeric attributes getting fed into the machine learning system. Different types of algorithms can be used for modelling, as long as the gradient is measured at the end. In one embodiment, a linear function is used to model with some activation function that makes it easy to calculate the gradient at the end. The data set in the above example is relatively simple so learning will be quick and accurate. Real world data is generally much more complicated, requiring a larger network, but the same principle applies.

After the machine learning for determining the time to approve the quote, as disclosed above, embodiments then perform machine learning to determine the likelihood that the quote will be approved. FIG. 2A illustrates a neural network in accordance with embodiments of the invention. Network 200 includes three layers: layer 201 has 4 linear neurons, layer 202 has 2 linear neurons, and layer 203 has a single neuron with a sigmoid activation function on it. The input 220 includes 31 attributes, and the output 221 includes a single number. In other embodiments, more complex networks can be used, including networks where the linear layers learn weights for the inputs and the sigmoid last layer allows for a non-linear function. Other embodiments of networks can, for example, have a non-linear node in the network and the last layer could be any activation function to map output to a 0 to 1 value range.

FIG. 2B is a plot illustrating what is learned in accordance to embodiments. In FIG. 2B, the x-axis is the row number of the input data and the y-axis is the output likelihood. As shown in FIG. 2B, the predicted and actual values lie nearly on top of each other.

Embodiments next recommend which attributes to change and what to do with them. This is considered “perfect learning” because the error in the machine learning came out to be 0. It can perfectly predict all data points in the training data set. The data that was passed in is very clean. At this point, embodiments can allow for a selection of an input variable and check what the gradient is at this point. The network that has been disclosed above reduces ultimately to the following function:

$$f(x)=1/(1+e^{-(Mx)})$$

This is because linear functions of linear functions are linear functions. The deep network of linear function can therefore be represented as a single linear multiplier. In this case, both M and x are vectors so x breaks down into (x1,

x2, x3, . . . , xn) as does M. Therefore, Mx is really (M1, M2, M3, . . . , Mn). The gradient calculation for this function is:

$$f(x)=f(x)*(1-f(x))*M$$

This derives from the definition of the sigmoid function (1/(1-e^{-x})) and the chain rule. More complicated, non-linear networks will result in more complicated gradients,

FIG. 3 illustrates the gradient at a specific point in accordance to embodiments for each of the attributes. There are categorical and numeric attributes. For numeric attributes (N5-N10), it is shown that N7 spikes high at 301. There are two things to derive from FIG. 3. First, the gradient value for the N7 attribute is large. This means that as N7 changes those changes will have a high impact on the likelihood of approval. Second, the value is positive, meaning that as N7 rises so does approval likelihood. This is consistent with expectations, as it is known that values of N7 below 40 are not approved, Categorical attributes can be more difficult. C2 has been split into 8 different input variables at 302, with each one being on or off (a one hot encoded vector). The gradient for each one of these subcategories shows great variation. The gradient component for C2 has a highly negative value at (1,0,0,0,0,0,0,0), or 0, or selecting 0 for that attribute (turning the “0 feature” on) means that the likelihood of an approval will drop significantly. For value 6 on C2, of (0,0,0,0,0,0,1,0) the gradient component is positive, meaning that it positively influences the approval.

The other categorical attributes have no differentiation between the distinct values. There are no peaks in the gradient curve, but a plateau. Similarly, for numeric attributes that do not drive approval, their gradient component is near 0, Therefore, attributes can be derived that drive the likelihood of approval with the following rules:

For numeric attributes, gradient values for each attribute (the derivative with respect to that attribute) that are large in magnitude will have a large impact on the approval value.

For categorical attributes, the attributes that are the highest driver of approval are those with the greatest difference between the vector components of the measured gradient.

The following application of the Example 1 uses C2 and N7 values, as all other attributes are meaningless as indicated in FIG. 3:

1. C2=0, N7=30. Embodiments will predict an approval likelihood of 3.48499E-40, which is very low. The analysis of N7 recommends that its value get increased. The analysis of C2 recommends that it go to the highest derivative value (i.e., 6). If C2 is changed to 6, the approval likelihood rises to 0.17%. This is still very low, but indicates that the example is on the cusp of getting a good approval likelihood. If N7 is raised from 0.3, to 0.4, the likelihood of approval rises to 99.86%, which is good.
2. C2=1, N7=30. The predicted likelihood for this scenario is 5.42179E-08, which is very low. Embodiments

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will recommend that N7 increase in value. The higher the N7, the higher the approval likelihood. When looking at C2, it will determine that the optimized value of C2 is 6, but the difference in their individual gradient components is small so the recommendation is weak. Instead, embodiments will just recommend N7 to go higher. If N7=40, there is a 2.21% likelihood of approval. If N7=45, there is a 93.60% likelihood of approval.

3. C2=6, N7=70. The predicted likelihood for this scenario is an approval 100% of the time. The gradient will actually be 0 in all cases (see gradient formula above) so no recommendation can be made.
4. C2=6, N7=50. This predicts an approval likelihood of 99.9999997%. The gradient will not be 0, but be very small. In this case, embodiments will still recommend increasing N7, but the increase will be a weak recommendation.

From the above examples, it is shown that the scale of the gradient does not change shape, but does in fact change

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magnitude. This is a consequence of the simplicity of the model used in the examples. However, in embodiments that use more complex models, this may not be the case. In general, embodiments not only learn the approval likelihood, but give a recommendation about the actions to take to increase it.

Example 2

In Example 2, the same dataset from Example 1 is used but the analysis is for the purpose of determining the time to approve a quote. In this embodiment, the learning algorithm is changed from a categorical learning algorithm to learning a trend line of the data. In this embodiment, for all of the data that are not approved because it the quote was never approved, the approval time has no meaning. In this example some extra data is added to the set from Example 1 to learn on that will have some different values for N7:

Category C1	Category C2	Category C3	Category C4	Number N5	Number N6	Number N7	Number N8	Number N9	Number N10	Output - Time
0	1	3	0	7.208027	82.13275	50	99.46205	329.6829	73.97227	5
1	1	2	3	9.203772	9.56518	60	95.41336	592.0796	25.45766	6
2	1	2	1	6.875848	94.41892	70	11.07896	913.0914	18.96652	7
2	1	5	6	0.541092	83.22869	80	6.682563	47.60813	99.64588	8
0	1	2	1	5.124998	3.119086	90	32.54647	556.2995	0.449008	9
1	1	2	6	9.542795	77.72751	100	78.2877	745.5394	26.13156	10
2	3	1	6	4.726675	3.059526	48	43.23626	464.6885	15.25987	4
0	3	0	1	9.555522	10.39694	58	53.78839	703.9343	69.54174	5
2	3	0	7	0.495636	22.76949	68	63.24197	711.8418	42.45497	6
0	3	1	0	6.751326	71.10343	78	22.58962	526.9667	63.65593	7
2	3	0	4	6.237391	46.48729	88	93.43233	669.0007	82.12466	8
2	3	0	7	6.238268	96.98076	98	58.82813	358.2252	91.69767	9
1	5	4	1	2.266866	96.31761	50	36.82894	949.4385	57.11249	5
1	5	5	6	3.051407	20.27506	60	29.42651	906.9905	34.24244	6
1	5	1	1	3.105064	19.67657	70	27.2733	539.5348	76.87418	7
1	5	4	0	2.199206	97.20728	80	44.46676	771.6103	57.26193	8
2	5	0	7	6.564856	12.91607	90	14.67403	801.3764	27.59289	9
2	5	2	5	5.648447	48.22651	100	39.85244	820.7555	49.8088	10
1	6	3	0	2.40397	23.35717	42	37.54332	943.6239	7.299102	4
0	6	4	5	5.330856	1.190311	52	28.6943	16.15862	12.90661	5
0	6	4	3	3.529218	9.544342	62	8.384189	515.5627	8.713614	6
1	6	4	1	5.661197	1.007811	72	73.41749	795.7179	81.2655	7
1	6	0	3	1.936352	8.484136	82	28.90585	920.911	0.104209	8
0	6	3	2	1.767537	72.44686	92	23.59219	916.3472	99.01434	9
0	1	3	0	7.208027	82.13275	10	99.46205	329.6829	73.97227	50
1	1	2	3	9.203772	9.56518	20	95.41336	592.0796	25.45766	40
2	1	2	1	6.875848	94.41892	30	11.07896	913.0914	18.96652	30
2	1	5	6	0.541092	83.22869	80	6.682563	47.60813	99.64588	8
0	1	2	1	5.124998	3.119086	90	32.54647	556.2995	0.449008	9
1	1	2	6	9.542795	77.72751	100	78.2877	745.5394	26.13156	10
2	3	1	6	4.726675	3.059526	8	43.23626	464.6885	15.25987	60
0	3	0	1	9.555522	10.39694	18	53.78839	703.9343	69.54174	50
2	3	0	7	0.495636	22.76949	28	63.24197	711.8418	42.45497	40
0	3	1	0	6.751326	71.10343	38	22.58962	526.9667	63.65593	30
2	3	0	4	6.237391	46.48729	88	93.43233	669.0007	82.12466	8
2	3	0	7	6.238268	96.98076	98	58.82813	358.2252	91.69767	9
1	5	4	1	2.266866	96.31761	50	36.82894	949.4385	57.11249	5
1	5	5	6	3.051407	20.27506	60	29.42651	906.9905	34.24244	6
1	5	1	1	3.105064	19.67657	70	27.2733	539.5348	76.87418	7
1	5	4	0	2.199206	97.20728	80	44.46676	771.6103	57.26193	8
2	5	0	7	6.564856	12.91607	90	14.67403	801.3764	27.59289	9
2	5	2	5	5.648447	48.22651	100	39.85244	820.7555	49.8088	10
1	6	3	0	2.40397	23.35717	2	37.54332	943.6239	7.299102	60
0	6	1	5	5.330856	1.190311	12	28.6943	16.15862	12.90661	50
0	6	4	3	3.529218	9.544342	22	8.384189	515.5627	8.713614	40
1	6	4	1	5.661197	1.007811	72	73.41749	795.7179	81.2655	7
1	6	0	3	1.936352	8.484136	82	28.90585	920.911	0.104209	8
0	6	3	2	1.767537	72.44686	92	23.59219	916.3472	99.01434	9

This is the same data set as in Example 1 above, but includes some extra records where N7 is less than 40. Since these lines are not optimal, the time of approval is high. In order to learn this, the neural network is revised to a more complicated definition in contrast to Example 1.

FIG. 4A illustrates a neural network 400 that can be used to predict approval time to approve a quote in accordance to an embodiment of the invention. In comparison to network 200, network 400 is a more complex network. The output 401 is not necessarily linear so a non-linear component is added to network 400. In the first layer 402 of the network, tan h nodes (i.e., non-linear components) are followed by linear nodes in the second layer 403, 404. This ensures that the non-linear function can be modeled and the linear nodes make sure a full function map to the output can be performed. As a result, output 401 gets modelled with this network as shown in graph 441 in FIG. 4B (reordered to be an increasing graph (i.e., would look similar to the graph of FIG. 2B if the data was ordered differently in the x-axis)).

As shown, network 400 has learned the trend well. The gradient of this function is such that it is significantly different depending on the particular point because the tan h function does not have a constant gradient. Looking at the value at individual points, one would expect to see the attribute with the greatest gradient to be the one where a change will affect the output to the greatest extent. For example, looking at a test point that maps to 20 days as shown on graph 501 of FIG. 5A:

Input: 1,1,2,3,1.486538744,71.60306092,36,4.996422959,341.2976196,56.0979154,20

There is a spike in attribute N7 (at 505). That means that this attribute is going to be the biggest impact on the output. This is what is expected based upon the relationship that was coded into the input data. Graph 502 of FIG. 5B displays another input:

Input: 0,2,3,1,6.505569615,79.42243533,45,56.91429068,128,577184,37.55258624,4

Here, the curve looks very similar, but the scale here is completely different. N7 spikes above all other attributes (at 515), but the magnitude of all attributes is reduced. This is because the level that is being modeled to is smaller.

As shown in FIGS. 5A and 5B, this is a simple relationship. There are no other attributes to learn a relationship with since N7 is the sole driver in this scenario. However, as can be seen at all points (2 examples included) N7 stands above other attributes on the gradient graph, meaning that it is the attribute that would be singled out to recommend a change in order to change the approval time value. Therefore, for an approvals type question, an action recommendation can be determined from the overall gradient calculation.

Approval Status Indicators

Embodiments provide the user viewing the quote with a visual indication of the route that is required for the quote to become approved. Users ready to submit for an approval will benefit from a visual inspection of the approval tree to see which nodes in the tree will be active for approval. The core components are a visual display of the complexity of the hierarchy showing each node. The tree object can be drilled into to view details about the approvers and the rules that have kicked off to active that node.

FIGS. 6A-6C illustrate graphical user interfaces that are presented to a user as part of the quote approval process in accordance to one embodiment. As shown in FIG. 6A, an icon indicator is rendered on an Approval tab 601. If all approval requirements have been satisfied (including if no

approvals are needed) then the icon is a green checkmark. If one or more approvals are required then the icon is a warning indicator, as shown in FIG. 6A.

Within the contents of the Approval tab (FIGS. 6B and 6C) a hierarchical graph 602 or 603 is rendered to show the status of approval requirements. Each approval step corresponds with an icon in a hierarchical graph. In addition to color as an indicator of status, a user can focus, click, and mouse-over the icons to view a tooltip with full information. As an example, Grey can indicate that approval is required (the reason evaluated to true), and no action has yet been returned. Green can indicate the approval has been satisfied (approved or none needed). Red can indicate that an approval step was rejected.

As disclosed above, the approvals likelihood indication is a machine learned value. The approval server/system will look upon historical data to learn a trend of how input attributes will affect the output likelihood of getting an approval. In addition to giving a value for the likelihood of an approval for the quote overall, embodiments will show how to change and the direction to change specific attribute values to increase the likelihood of getting an approval.

Similarly, the approvals time indication is also a machine learned value and will display to the user the anticipated time that it will take to get an approval of a quote.

As disclosed, for the approvals likelihood and time indicators, a neural network model is generated. Input in this scenario will be the list of all appropriate attributes on the quote that is entering the approval stage. Further, in embodiments, clearly non-determining attributes are excluded. For example, in one embodiment the following attributes are cleansed off of the quote:

HTML attributes.

RTE attributes.

Distinct ID attributes (quote ID, document ID, etc. . . .).

Constant attributes (attributes the same on every quote).

Once this cleansing is complete, the remaining attributes will be a subset ready to be fed into the neural network learning system. In embodiments, numeric attributes need to be normalized to be between 0 and 1 and categorical attributes needs to be turned into one hot encoded vectors. As an example of a hot encoded vector, assume that an attribute for hair color that can be Brown, Black, or Blonde, for a categorical attribute with 3 categories. It could be represented numerically many ways. For example, Brown can be mapped to 1, Black to 2, and Blonde to 3. However, a machine would learn that Blonde>Black>Brown by the nature of how they have been mapped. This is undesirable because that relationship does not exist. Instead, embodiments map them to a one hot encoded vector, which will establish a component for each attribute and it will be a 0 if it is not selected or a 1 if it is. In that case Brown is [1,0,0], Black is [0,1,0], and Blonde is [0,0,1].

For approval likelihood, using a one hot encoded vector for categorical inputs works well into a standard logistic regression. The depth and width of the network will depend upon the complexity of the input. In one embodiment, the initial network layer requires at least as many nodes as inputs, and there is no need for more than 3 layers to get acceptable learning rates in all cases.

As disclosed, mapping time to approval can be a more complicated network. This is not a linear regression problem because the relationship to attributes will not be linear. The real trend line will look more like a step function as attributes will trigger a new approval node once they exceed a rule specified value, adding in a new step in approval.

Therefore, a non-linear network is used to model. The width of the network should be as big as the list of attributes.

In embodiments, for predicting likelihood of approval, a history of failed approvals first needs to be stored. From the history of failed and successful quotes, embodiments can learn what quotes are most likely to get approved and then provide a predictor on a quote for how likely it is to be approved. Users can use this value to get insight into what they should do to the quote to make approval more likely.

Embodiments also are able to make a recommendation for what attributes could be changed to make the approval most likely to get approval.

In embodiments for approval likelihood, the neural network is a standard binary network. Because win rate quotes can be mapped to either a win or a loss, so too can an approval action map to either an approve or reject. Embodiments use a logistic regression where the input is the set of attributes on the quote at the time when the approve or reject took place.

Embodiments receive historical data for both approved and rejected quote and that data undergoes a process of preparation before they can be fed into the learning network. Next, this input is fed into the logistic regression.

FIG. 7A illustrates example graphical user interfaces that provide the output of approval likelihood to the user in accordance to embodiments. The output may be provided as a bar gauge **701** or a circular gauge **702**, and may be implemented using a JET UI.

Embodiments also maintain the length of time for an approval from the workflow. This data can be used to measure the time that it took for approved quotes to go from submitting the approval to the approval getting completed. With this data, embodiments learn how long a quote is expected to be in approval based upon the current quote's attributes. The approval time can be broken down to show the time to approve on every step in the approval.

Time approval prediction is also a machine learning system. The input variables are attributes on the quote and the output will be a single numeric value which will be the anticipated time the approval will take. For training, embodiments consume variables of approved quotes for input and the time taken to go through the submitted step to the finalized step in the workflow table. Previous rejections can be ignored. It is assumed that no changes were made to the quote after the quote was approved. Only the data showing the approval time need to be pulled from the historical record with the approval system and pre-processed before they are fed into the machine learning network in embodiments.

In embodiments, the data model for determining the approval time is a linear regression model. Embodiments create a linear model mapping all quote attributes into the model. They will be mapped to the approvals time from the above query.

FIG. 7B illustrates example graphical user interfaces that provide the output of predicted approval time to the user in accordance to embodiments. The output may be provided as a bar gauge **711** or a circular gauge **722**, and may be implemented using a JET UI.

FIG. 8 is a flow diagram of the high level functionality of quote approval module **16** of FIG. 1 when providing enhanced quote approval functionality for a CPQ in accordance with one embodiment. In one embodiment, the functionality of the flow diagram of FIG. 3 is implemented by software stored in memory or other computer readable or tangible medium, and executed by a processor. In other embodiments, the functionality may be performed by hard-

ware (e.g., through the use of an application specific integrated circuit ("ASIC"), a programmable gate array ("PGA"), a field programmable gate array ("FPGA"), etc.), or any combination of hardware and software.

At **802**, a configurator generates a quote for a product or service configuration. The quote is generated through user interaction with the configurator and includes a quote workflow that includes at least one required quote approval. The quote also includes a plurality of quote attributes that define the quote.

At **804**, the quote attributes are input to at least two different trained neural networks (i.e., neural network models). One of the neural network has been trained using past quotes and attributes and is configured to predict the likelihood that a quote will be approved. One of the neural network has been trained using past quotes and attributes and is configured to predict the time required for the quote to be approved.

At **806**, the neural networks generate the likelihood that a quote will be approved and the time required for the quote to be approved, each of which is generated with gradient descent.

At **808**, each of the neural networks generate the attributes with the largest gradient values to identify those attributes that can be modified to substantially change either the likelihood that a quote will be approved or the time required for the quote to be approved.

At **810**, one or more of the identified attributes at **808** are changed and the likelihood that a quote will be approved and/or the time required for the quote to be approved are recalculated.

As disclosed, embodiments include a configuration or CPQ system that is enhanced to provide to the user prediction on the likelihood that a quote will be approved and the time required for the quote to be approved based on machine learning and neural networks. Further, embodiments provide one or more attributes having a high gradient to inform that user that changing those attributes will have large impact on the predictions.

Several embodiments are specifically illustrated and/or described herein. However, it will be appreciated that modifications and variations of the disclosed embodiments are covered by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

What is claimed is:

1. A method of operating a configurator comprising:
 - generating a quote for a product or service configuration, the quote comprising a quote workflow that includes at least one required approval of the quote before the quote can be issued and the product or service configuration is offered for sale in a form of the quote, the quote comprising a plurality of quote attributes that define the quote and are provided as input to determine the at least one required approval;
 - receiving a historical set of quote attributes corresponding to a plurality of previous quotes and comprising a corresponding determination of whether each of the previous quotes was approved and/or a time taken to approve each of the previous quotes;
 - using the historical set of quote attributes to train a first neural network model and a second neural network model;
 - inputting the plurality of quote attributes into the first neural network model and a second neural network model;

generating at the first neural network model with a gradient descent a likelihood that the quote will be approved and at the second neural network model with the gradient descent a time required for the quote to be approved, wherein the gradient descent iteratively calculates the gradient of a loss function at each neuron and moves coefficient weights for each input attribute in a direction of a smaller loss;

generating one or more attributes with the largest gradient values for the likelihood that the quote will be approved and the time required for the quote to be approved; based on the gradient values, displaying an indication of changes to be made to the quote to optimize an approval length; and

in response to the display, receiving a change to one or more of the attributes and regenerating the likelihood that the quote will be approved and/or the time required for the quote to be approved based on the change.

2. The method of claim 1, wherein quote approvals of the quote comprise a graph of nodes.

3. The method of claim 1, wherein the quote attributes comprise at least one categorical attribute and at least one numeric attribute.

4. The method of claim 1, wherein the first neural network model comprises three layers, wherein two of the layers comprise linear neurons and a final layer comprises a sigmoid activation function.

5. The method of claim 4, wherein the first neural network model comprises $f(x)=1/(1+e^{-(Mx)})$ having a gradient comprising $f'(x)=f(x)*(1-f(x))*M$, wherein "f" is a function, and "M" and "x" are vectors and "e" is a mathematical constant.

6. The method of claim 1, wherein the second neural network model comprises three layers having a first input layer comprising non-linear components and a second and third layer comprising linear components.

7. The method of claim 3, wherein the at least one numeric attribute is normalized to be between 0 and 1 and the at least one categorical attribute is transformed into one hot encoded vectors.

8. A non-transitory computer readable medium having instructions stored thereon that, when executed by a processor, cause the processor to operate a configurator, the operating comprising:

generating a quote for a product or service configuration, the quote comprising a quote workflow that includes at least one required approval of the quote before the quote can be issued and the product or service configuration is offered for sale in a form of the quote, the quote comprising a plurality of quote attributes that define the quote and are provided as input to determine the at least one required approval;

receiving a historical set of quote attributes corresponding to a plurality of previous quotes and comprising a corresponding determination of whether each of the previous quotes was approved and/or a time taken to approve each of the previous quotes;

using the historical set of quote attributes to train a first neural network model and a second neural network model;

inputting the plurality of quote attributes into the first neural network model and a second neural network model;

generating at the first neural network model with a gradient descent a likelihood that the quote will be approved and at the second neural network model with the gradient descent a time required for the quote to be approved, wherein the gradient descent iteratively cal-

culates the gradient of a loss function at each neuron and moves coefficient weights for each input attribute in a direction of a smaller loss;

generating one or more attributes with the largest gradient values for the likelihood that the quote will be approved and the time required for the quote to be approved; based on the gradient values, displaying an indication of changes to be made to the quote to optimize an approval length; and

in response to the display, receiving a change to one or more of the attributes and regenerating the likelihood that the quote will be approved and/or the time required for the quote to be approved based on the change.

9. The non-transitory computer readable medium of claim 8, wherein quote approvals of the quote comprise a graph of nodes.

10. The non-transitory computer readable medium of claim 8, wherein the quote attributes comprise at least one categorical attribute and at least one numeric attribute.

11. The non-transitory computer readable medium of claim 8, wherein the first neural network model comprises three layers, wherein two of the layers comprise linear neurons and a final layer comprises a sigmoid activation function.

12. The non-transitory computer readable medium of claim 11, wherein the first neural network model comprises $f(x)=1/(1+e^{-(Mx)})$ having a gradient comprising $f'(x)=f(x)*(1-f(x))*M$, wherein "f" is a function, "M" and "x" are vectors and "e" is a mathematical constant.

13. The non-transitory computer readable medium of claim 8, wherein the second neural network model comprises three layers having a first input layer comprising non-linear components and a second and third layer comprising linear components.

14. The non-transitory computer readable medium of claim 10, wherein the at least one numeric attribute is normalized to be between 0 and 1 and the at least one categorical attribute is transformed into one hot encoded vectors.

15. A product configurator comprising:

a first neural network model;

a second neural network model; and

one or more processors configured to:

generate a quote for a product or service configuration, the quote comprising a quote workflow that includes at least one required approval of the quote before the quote can be issued and the product or service configuration is offered for sale in a form of the quote, the quote comprising a plurality of quote attributes that define the quote and are provided as input to determine the at least one required approval;

receive a historical set of quote attributes corresponding to a plurality of previous quotes and comprising a corresponding determination of whether each of the previous quotes was approved and/or a time taken to approve each of the previous quotes;

use the historical set of quote attributes to train the first neural network model and the second neural network model;

input the plurality of quote attributes into the first neural network model and the second neural network model;

generate at the first neural network model with a gradient descent a likelihood that the quote will be approved and at the second neural network model with the gradient descent a time required for the quote to be approved, wherein the gradient descent

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iteratively calculates the gradient of a loss function at each neuron and moves coefficient weights for each input attribute in a direction of a smaller loss;
 generate one or more attributes with the largest gradient values for the likelihood that the quote will be approved and the time required for the quote to be approved;
 based on the gradient values, display an indication of changes to be made to the quote to optimize an approval length; and
 in response to the display, receive a change to one or more of the attributes and regenerating the likelihood that the quote will be approved and/or the time required for the quote to be approved based on the change.

16. The product configurator of claim 15, wherein the quote attributes comprise at least one categorical attribute and at least one numeric attribute.

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17. The product configurator of claim 15, wherein the first neural network model comprises three layers, wherein two of the layers comprise linear neurons and a final layer comprises a sigmoid activation function.

18. The product configurator of claim 17, wherein the first neural network model comprises $f(x)=1/(1+e^{-Mx})$ having a gradient comprising $f'(x)=f(x)*(1-f(x))*M$, wherein “f” is a function, and “M” and “x” are vectors and “e” is a mathematical constant.

19. The product configurator of claim 15, wherein the second neural network model comprises three layers having a first input layer comprising non-linear components and a second and third layer comprising linear components.

20. The product configurator of claim 16, wherein the at least one numeric attribute is normalized to be between 0 and 1 and the at least one categorical attribute is transformed into one hot encoded vectors.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 11,615,289 B2
APPLICATION NO. : 16/021245
DATED : March 28, 2023
INVENTOR(S) : Wilkins et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification


In Column 4, Line 31, delete “soft are” and insert -- software --, therefor.

In Column 10, Line 28, delete “approved,” and insert -- approved. --, therefor.

In Column 10, Line 43, delete “0,” and insert -- 0. --, therefor.

In Columns 11-12, Line 41, delete “4” and insert -- 1 --, therefor.

In Column 13, Line 2, delete “40,” and insert -- 40. --, therefor.

Signed and Sealed this
Thirteenth Day of February, 2024


Katherine Kelly Vidal
Director of the United States Patent and Trademark Office